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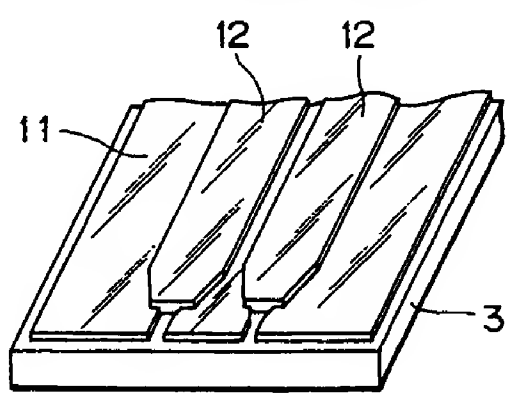
(54) A process for producing at least one resistor component.

(57) A process for producing at least one resistor component comprising applying to a substrate (3) a layer (11) of heat-softenable insulating material having at least one slit-shaped opening (10) therein; heating the insulating material so that the latter flows and its outer surface is provided with at least one ridge (2); and forming at least one resistor (8) on the or each said ridge (2), the or each resistor (8) being connected to a respective electrically conductive member (9) by means of which power may be transmitted to the respective resistor (8), characterised in that a second layer (12) of insulating material is employed which is disposed in the or each slit-shaped opening (10) so as to extend to a level above that of the first-mentioned layer (11).

FIG.3(A)



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A PROCESS FOR PRODUCING AT LEAST ONE RESISTOR COMPONENT

This invention concerns the production of resistor components which may, for example, be used in producing thermal heads for printers.

A process for producing such resistor components is known to the Applicants. In this prior process a glass paste is printed in a pattern of adjacent parallel bands on the principal surface of a substrate by a screen printing method. The glass paste is then treated by heating to form a ridge-shaped glaze layer having an arcuate section. A plurality of isolated individual resistors are then formed by patterning after electrically resistive material has been deposited in the vicinity of the ridge-shaped glaze layer. Lastly, a plurality of isolated individual tracks are formed by patterning after electrically conductive material has been deposited on the substrate. Each of the tracks is connected at one end to a respective resistor so that electrical power may be applied to the respective resistor.

In this prior process, the substrate has been made of ceramics. Those parts of the substrate which have not been provided with the glaze layer have porous surfaces whose roughness is about 1μm so that they are liable to cause defects such as shorted or broken electrically conductive tracks. Due to a fine difference in the wettability between the principal surface of the substrate and the glass paste, moreover, the width of the glaze layers is liable to change or their surfaces may become undulating, so that adjacent glaze layers may merge into each other.

According to the present invention, there is provided a process for producing at least one resistor component comprising applying to a substrate a layer of heat-softenable insulating material having at least one slit-shaped opening therein; heating the insulating material so that the latter flows and its outer surface is provided with at least one ridge; and forming at least one resistor on the or each said ridge, the or each resistor being connected to a respective electrically conductive member by means of which power may be transmitted to the respective resistor, characterised in that a second layer of insulating material is employed which is disposed in the or each slit-shaped opening so as to extend to a level above that of the first-mentioned layer.

Preferably, each said layer is of glass paste.

The first-mentioned layer preferably has a plurality of parallel slit-shaped openings therein, the said heating producing a plurality of ridges.

Preferably, after the formation of the resistors and electrically conductive members, the substrate is divided into a plurality of components each of which has at least one resistor and a respective electrically conductive member thereon.

The second layer may be in the form of a plurality of bands each of which fills the respective slit-shaped opening and extends onto adjacent portions of the first-mentioned layer.

Preferably, the insulating material of the second layer has a higher softening temperature than that of the first-mentioned layer; the said heating being effected at a temperature higher than that of the second layer.

A further layer of heat-softenable insulating material may be formed along at least one edge of the substrate so as to reduce variation in ridge shape.

Means are preferably provided for reducing the chance of merger between adjacent portions of the second layer as a result of the said heating.

Thus each slit-shaped opening may be provided between a major portion and a minor portion of the first-mentioned layer, the said minor portions being arranged in pairs with a slit-shaped space between the members of each pair.

The invention also comprises a thermal head for a printer when produced by the process set forth above.

By means of the present invention it is thus possible to produce a thermal head which has a ridge-shaped glaze structure including a plane glaze layer and a ridge-shaped glaze layer or layers with facility and high productivity. It is also possible to produce a plurality of thermal heads each having a ridge-shaped glaze structure from a common substrate with facility and high productivity.

In the preferred process of the present invention, a first glass paste is printed by a screen printing method on the principal surface of a substrate in a pattern having a plurality of adjacent slit-shaped openings which are parallel to each other.

Next, a second glass paste is printed in a pattern having independent bands which cover the openings.

After these steps, a heating step is employed in which the first and second glass pastes are melted and hardened simultaneously so that the substrate has a ridge-shaped glazed structure thereon which consists of a plane glaze layer and a ridge-shaped glaze layer.

Next, a plurality of isolated individual resistors are formed by patterning after an electrically resistive material has been deposited in the vicinity of the ridge-shaped glaze layer. Further, a plurality of isolated individual tracks are formed by patterning after electrically conductive material has been deposited on the substrate.

In this case, the second glass paste has a higher softening temperature than that of the first glass paste so that the ridge-shaped glazed structure can be produced. By employing means comprising slit-shaped spacing between the adjacent openings, the adjacent ridge-shaped glaze layers can be prevented from merging. Since the desired portions of the principal surface of the substrate can be coated with the glaze layer, the substrate can have a smooth surface. Thus, if the substrate is made of ceramics, patterning possibilities are increased. Alternatively, the smooth surface may be that of an insulating coating on a substrate made of metal. Further, the first and second glass pastes can be printed in a matrix of the aforementioned patterns on one large substrate so that a plurality of thermal heads can be produced from one substrate.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:-

Figures 1(A), 1(B) are a perspective view and a sectional view of a glazed substrate which may be produced by the process of the present invention;

Figures 2(A), 3(A) are perspective views and Figures 2(B), 3(B) are sectional views illustrating steps in a process for producing the glazed substrate shown in Figures 1(A), 1(B);

Figures 4(A) - 4(D) and 4(AA) - 4(DD) are sectional views illustrating the relationship between the patterns of glass pastes employed in the production of the said glazed substrate and the shape of the glaze layer on the substrate;

Figure 5 is a sectional view illustrating steps in the process of the present invention which may be used after glaze layers have been formed on the substrate;

Figure 6 is a perspective view of an edge-shaped thermal head which may be produced by the process of the present invention;

Figure 7 is a sectional view illustrating an alternative embodiment of the steps which may be used in the process of the present invention;

Figure 8 is a sectional view of a thermal head having two ridge-shaped glaze layers which may be produced by the process of the present invention;

Figure 9 is a sectional view illustrating another embodiment of the steps which may be used in the process of the present invention;

Figure 10 is a perspective view of a thermal head having two ridge-shaped glaze layers which may be produced by the process of the present invention;

Figures 11(A) - 11(D) are sectional views illustrating a further embodiment of the steps which may be used in the process of the present invention; and

Figures 12(A) to 12(D) are sectional views illustrating yet another embodiment of the steps which may be used in the process of the present invention.

Figures 1(A), 1(B) are a perspective view and a sectional view respectively of a glazed substrate which is produced in one embodiment of a process according to the present invention.

A glazed substrate 4 includes a rectangular substrate 3 and a ridge-shaped glaze layer 1, 2 thereon. The substrate 3 is a flat plate and is constructed of a material, such as ceramics, such that it acts both as an electrical insulator and as a heat sink for the thermal energy created by the operation of a print head (not shown). Over a principal surface of the substrate 3, there is formed the said ridge-shaped glaze layer which comprises a first glaze layer 1 and strips of a second glaze layer 2 contacting the first glaze layer 1. The principal surface of the substrate 3 is mostly coated with the first and second glaze layers 1, 2 so that the glazed substrate 4 has a smooth and continuous surface made of amorphous glaze.

The process of forming the glazed substrate 4 will now be described.

A first glass paste 11 is formed by a screen printing method in a pattern having a plurality of adjacent, parallel, slit-shaped openings 10 which extend over the principal surface of the substrate 3, as shown in Figures 2(A), 2(B). Next, separate bands of a second glass paste 12 are formed by the screen printing method so as to cover the slit-shaped openings 10, as shown in Figures 3(A), 3(B). Each such band is formed by introducing the second glass paste 12 into the respective slit-shaped opening 10 so as to fill the latter and extend to a level above that of the first glass paste 11, each such band extending onto each adjacent band of first glass paste 11. The second glass paste 12 has a higher softening temperature than that of the first glass paste 11. The width of each band of the second glass paste 12 is slightly larger than that of the respective opening 10 of the first glass paste 11. The first and second glass pastes may be printed in any order.

After these printing steps, the first and second glass pastes 11, 12 are melted and hardened by heat treatment at a temperature higher than the softening temperature of the second glass paste 12 so that the glazed substrate 4 having the ridge-shaped glaze layer shown in Figures 1(A), 1(B) is obtained. It is preferred that the softening temperature difference between the first and second glass pastes 11, 12 is 50°C to 200°C and that the temperature for the heat treatment is higher by 200°C to 400°C than the softening temperature of the second glass paste 12.

The shape of the glazed substrate 4 will now

be described.

Figures 4(A) - 4(D) and 4(AA) - 4(DD) respectively relate to glazed substrates 4 in which there are changes in the gap a between the openings 10 in the printed pattern of the first glass paste 11 and in the gap b between the bands of the second glass paste 12.

When the gaps a , b . are considerable, as shown in Figures 4(A), 4(B), the glazed substrate 4 has a substantially planar first glaze layer 1, a ridge-shaped second glaze layer 2, and small dents or recesses 6 which are formed at the lowermost portions of the ridge-shaped second glaze layers 2, as shown in Figures 4(AA), 4(BB). As the gaps a , b are made smaller, the adjacent second glaze layers 2 come closer to each other. The recesses 6 between the adjacent second glaze layers 2 come closer to each other until they merge to form one U-shaped valley 5, as shown in Figure 4(CC). If, however, the gaps a , b are further reduced, as shown in Figure 4(D), the second glaze layers 2 merge to form substantially one ridge 7, as shown in Figure 4(DD). It is preferred that the gaps a , b for forming the glazed substrate 4 shown in Figure 4(CC) are about 0.4 to 2.0mm although it depends upon the width c of the openings 10, the width d of the bands of second glass paste 12, and the nature of the first and second glass paste materials. Further, the gap g between the crests of the ridges of the second glaze layers 2 is about 1.7 to 2.5mm when the gaps c , d are about 1.5mm.

The aforementioned values a , b , c , d , g may be suitably selected, together with the thicknesses or heights of the first and second glaze layers 1, 2, in dependence upon the kind or application of the thermal head which it is desired to produce.

Figure 5 is a sectional view illustrating an embodiment of the steps which may be used after the glaze layers have been formed.

A plurality of isolated individual resistors 8 are formed by patterning after electrically resistive material has been deposited in the vicinity of the crests of the second glaze layers 2. Next, a plurality of isolated individual electrically conductive members or tracks 9 are formed by patterning after electrically conductive material has been deposited on the glazed substrate 4. Each of tracks 9 is connected at one end to the respective resistor 8 and is arranged to supply electrical power for generating heat to the respective resistor 8. It is preferred that a protective-passivating layer, which operates to protect the various elements deposited on the glazed substrate 4 from chemical or physical abrasion, is deposited over the area of the glazed substrate 4 so as to cover the surface of the resistors 8 at least. Lastly, the substrate 3 is divided into edge-shaped thermal heads, as shown in Figure 6, along snap lines 13 (Figure 5) formed at the back of the substrate 3, each such thermal head having a plurality of resistors 8 and respective tracks 9 thereon.

Figure 7 is a sectional view illustrating another embodiment of steps which may be used in the process of the present invention.

In the Figure 7 embodiment, the first glass paste 11 is formed on a large substrate 3 by the screen printing method in which the pattern shown in Figure 2(A) is arranged in a matrix. The second glass paste 12 is formed by the screen printing method in a pattern having independent bands which cover the slit-shaped openings 10. After these printing steps, the first and second glass pastes 11, 12 are melted and hardened by heat treatment at a temperature higher than the softening temperature of the second glass paste 12. Next, resistors 8 and tracks 9 are formed in the same way as in the aforementioned embodiment. As a result, the substrate shown in Figure 7 is obtained. Lastly, the substrate is divided into a plurality of edge-shaped thermal heads by snap lines 13 which are formed at the back of the substrate 3 and which correspond to the said matrix.

Further, the substrate can be divided into a plurality of thermal heads having two ridge-shaped glaze layers arranged parallel and adjacent to one another, as shown in Figure 8, by snap lines (not shown in Figure 8) formed between the adjacent first glaze layers 1 at the back of the substrate 3. In this case, it is desirable that a distance P between the resistors 8 formed on the two ridge-shaped glaze layers is formed as P = 2np (n = 1, 2, 3, ..., p = the pitch of the printing dots which are to be produced in operation by the thermal head). A printing apparatus using this thermal head can drive the resistors 8 alternately so that it can print at high speed.

Figure 9 is a sectional view illustrating a further embodiment of steps which may be used in the process of the present invention. The substrate 3 is formed with the ridge-shaped glaze layers in the same way as in the aforementioned embodiments. After the resistors 8 and the tracks 9 have been formed on the glaze layer, it is divided into a plurality of thermal heads having two lines of resistors 8, as shown In Figure 10, by snap lines 13 formed at the back of the substrate 3. In this case, dummy glaze layers 2a are formed at the outside of the outer second glaze layers 2. Because of the presence of the dummy glaze layers 2a, when the first and second glaze layers 1, 2 are melted by the heat treatment, the surface tensions, which are intrinsic when two or more different kinds of glass paste materials are used, are equal except at the dummy glaze layers 2a, so that there is little vari-

ation in the shapes of the second glaze layers 2.

Figures 11(A) - 11(D) are sectional views illustrating another embodiment of steps which may be used in the process of the present invention.

The first glass paste 11 is formed by the screen printing method in a pattern having a plurality of adjacent slit-shaped openings 14-1, 14-2, 14-3 which are arranged parallel to each other on the principal surface of the substrate 3, as shown in Figure 11(A). Next, the second glass paste 12 is formed by the screen printing method in a pattern comprising independent bands which cover the openings 14-1, 14-2, 14-3, as shown in Figure 11-(B). After these printing steps, the first and second glass pastes 11, 12 are melted and hardened by heat treatment in the same way as in the aforementioned embodiments so that a glazed substrate 4 is obtained, as shown in Figure 11(C). Further, resistors 8 and tracks 9 are formed on the glazed substrate 4. Lastly, the substrate 3 is divided into a plurality of thermal heads having three ridge-shaped glaze layers, as shown in Figure 11(D). This thermal head is utilized in an improved printing apparatus by arranging two such thermal heads in contact with each other.

Figures 12(A) - 12(D) are sectional views illustrating yet another embodiment of the steps which may be used in the process of the present invention.

The first glass paste is formed by the screen printing method in a pattern comprising major portions 11 and minor portions 11a which extend parallel to each other over the principal surface of the substrate 3, as shown in Figure 12(A). Each major portion 11 is spaced from an adjacent minor portion 11a by a slit-shaped opening 10. The minor portions 11a are in pairs thereof, the members of each pair being separated by a slit-shaped space 15.

Next, a second glass paste 12 is formed by the screen printing method in a pattern comprising independent bands which cover the openings 10, as shown in Figure 12(B).

After these printing steps, the first and second glass pastes 11, 12 are melted and hardened by heat treatment at a temperature higher than the softening temperature of the second glass paste 12 so that a glazed substrate 4 having a ridge-shaped glaze layer is obtained, as shown in Figure 12(C). Further, a plurality of isolated individual resistors 8 are formed by patterning after electrically resistive material has been deposited in the vicinity of the crests of the second glaze layers 2. Furthermore, a plurality of isolated individual tracks 9 are formed by patterning after electrically conductive material has been deposited on the glazed substrate 4. Each of tracks 9 is connected at one end to each of the resistors 8 and is arranged to apply electrical power thereto for generating heat in the resistors 8.

Lastly, the substrate 3 is divided into edge-shaped thermal heads by using the snap lines 13 formed at the back of the substrate 3 and/or second snap lines 16 formed in the front surface of the substrate 3 in alignment with the spaces 15, as shown in Figure 12(D). Because of the use of the spaces 15, when the first and second glass pastes 11, 12 are melted and hardened by heat treatment, the risk that the adjacent second glaze layers 2 will merge is reduced. The preferred width of the spaces 15 is 0.2mm at the minimum so as to ensure separation of the adjacent second glaze layers 2.

In the embodiments described above, it is possible to have stabilized shapes of the ridge-shaped glaze layers when they are formed adjacent to and parallel to each other over the principal surface of the substrate. Since the desired portions of the principal surface of the substrate can be coated with the first glaze layers, the substrate, if it is made of ceramics, can be provided with a smooth surface so as to increase the variety of the patterns which can be formed on it. The smooth surface can also be provided on an insulating coating if the substrate is made of a metal. Further, the principal surface of the substrate can be made smooth and continuous to enhance sliding performance with respect to an heat sensitive paper.

Claims

1. A process for producing at least one resistor component comprising applying to a substrate (3) a layer (11) of heat-softenable insulating material having at least one slit-shaped opening (10) therein; heating the insulating material so that the latter flows and its outer surface is provided with at least one ridge (2); and forming at least one resistor (8) on the or each said ridge (12), the or each resistor (8) being connected to a respective electrically conductive member (9) by means of which power may be transmitted to the respective resistor (8), characterised in that a second layer (12) of insulating material is employed which is disposed in the or each slit-shaped opening (10) so as to extend to a level above that of the first-mentioned layer (11).
2. A process as claimed in claim 1 characterised in that each said layer (11,12) is of glass paste.
3. A process as claimed in claim 1 or 2 characterised in that the first-mentioned layer has a plurality of parallel slit-shaped openings (10) therein, the said heating producing a plurality of ridges (2).
4. A process as claimed in claim 3 characterised in that, after the formation of the resistors (8) and electrically conductive members (9), the substrate (3) is divided into a plurality of components each of

which has at least one resistor (8) and a respective electrically conductive member (9) thereon.

5. A process as claimed in claim 3 or 4 characterised in that the second layer Is in the form of a plurality of bands (12) each of which fills the respective slit-shaped opening (10) and extends into adjacent portions of the first-mentioned layer (11).

6. A process as claimed in any preceding claim characterised in that the insulating material of the second layer (12) has a higher softening temperature than that of the first-mentioned layer; the said heating being effected at a temperature higher than that of the second layer (12).

7. A process as claimed in any preceding claim characterised in that a further layer (2a) of heat-softenable insulating material is formed along at least one edge of the substrate (3) so as to reduce variation in ridge shapes.

8. A process as claimed in claim 3 or in any claim appendant thereto characterised in that means (11a,15) are provided for reducing the chance of merger between adjacent portions of the second layer (12) as a result of the said heating.

9. A process as claimed in claim 8 characterised in that each slit-shaped opening (10) is provided between a major portion (11) and a minor portion (11a) of the first-mentioned layer (11), the said minor portions (11a) being arranged in pairs with a slit-shaped space (15) between the members of each pair.

10. A thermal head for a printer when produced by the process claimed in any preceding claim.

11. A process for producing a plurality of thermal heads, which has ridge-shaped glaze structure, from a substrate, the process comprising the steps of:

A. printing first glass paste (11) over said substrate (3) in the matrix of a pattern having a plurality of adjacent slit-shaped openings (10) in parallel,

B. printing second glass paste (12) in a pattern having such independent bands as cover said openings (10),

C. treating said first glass paste (11) and said second glass paste (12) by heating simultaneously for forming said ridge-shaped glaze structure (4) comprising plane first glaze layer (1) and ridge-shaped second glaze layer (2) on said substrate.

D. forming resistors (8) arrayed linearly across the crest of said second glaze layer (2) and traces (9) for applying electrical energy to said resistors (8) and

E. dividing said substrate (3) into a plurality of said thermal heads.

12. A process for producing thermal head, which has ridge-shaped glaze structure, the process comprising the steps of:

A. printing first glass paste in a pattern having a plurality of adjacent slit-shaped openings in parallel over a substrate.

B. printing second glass paste in a pattern having such independent bands as cover said openings,

C. treating said first glass paste and said second glass paste by heating simultaneously for forming said ridge-shaped glaze structure comprising plane first glaze layer and ridge-shaped second glaze layer, and

D. forming resistors arrayed linearly across the crest of said ridge-shaped second glaze layer and traces for applying electrical energy to said resistors.

FIG.1(A)

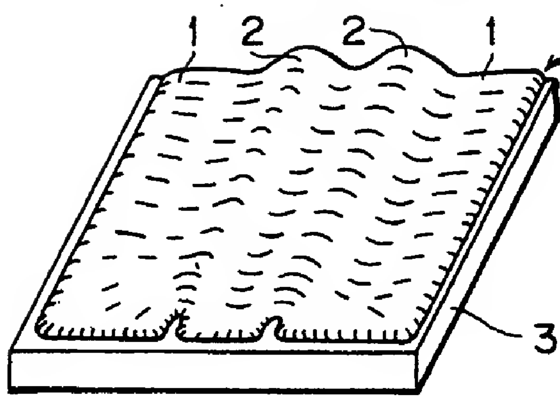

FIG.1(B)

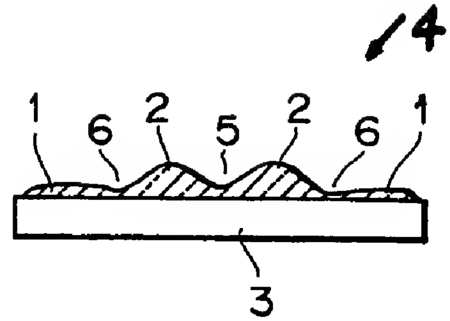

FIG.2(A)

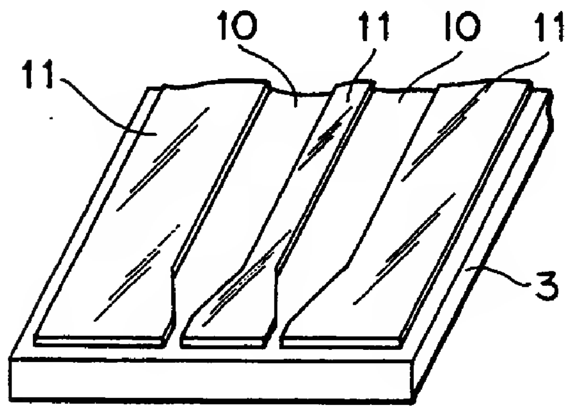

FIG.2(B)

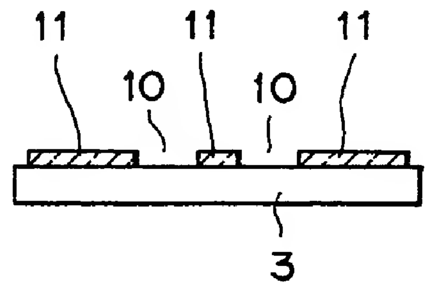

FIG.3(A)

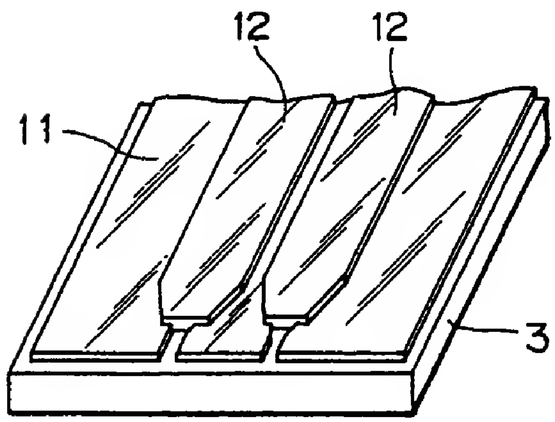

FIG.3(B)

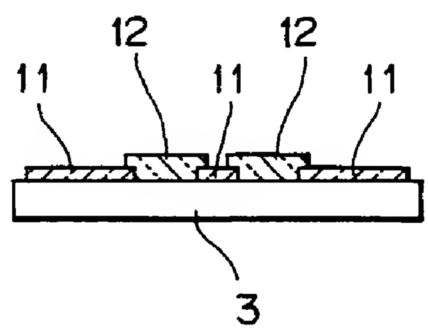

FIG. 4(A)

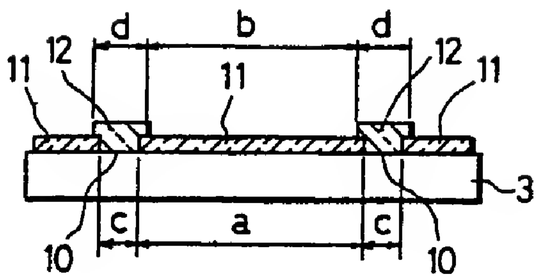

FIG. 4(AA)

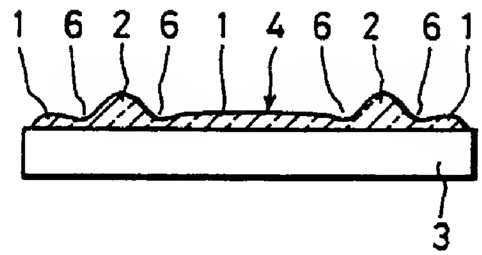

FIG. 4(B)

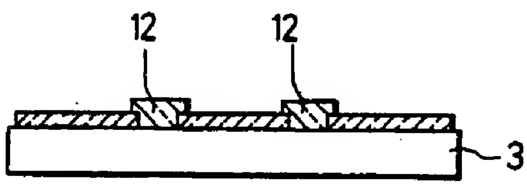

FIG. 4(BB)

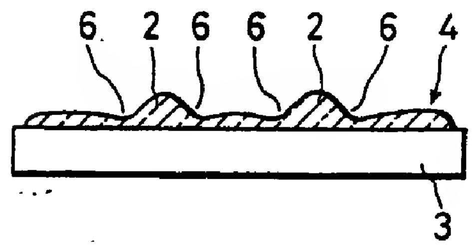

FIG. 4(C)

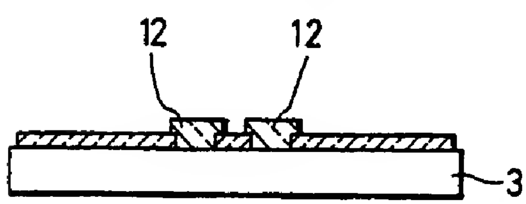

FIG. 4(CC)

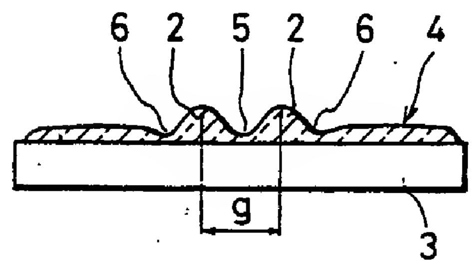

FIG. 4(D)

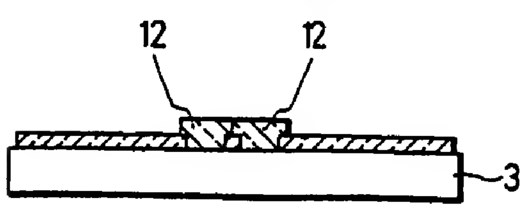

FIG. 4(DD)

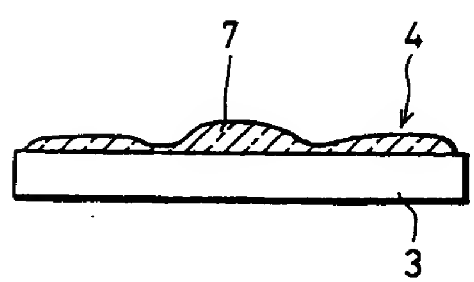

FIG. 5

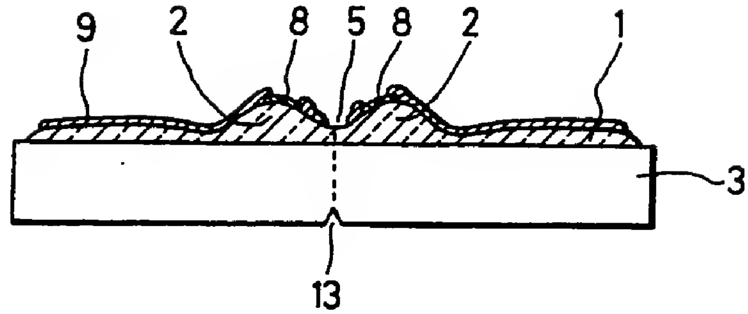

FIG. 6

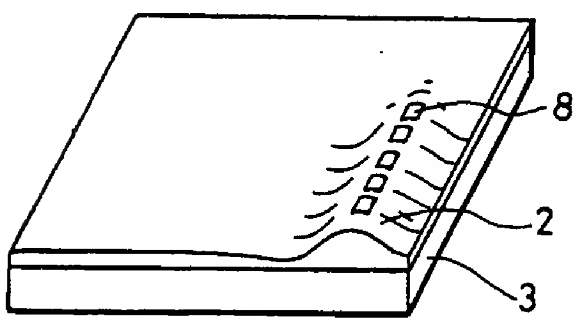

FIG. 7

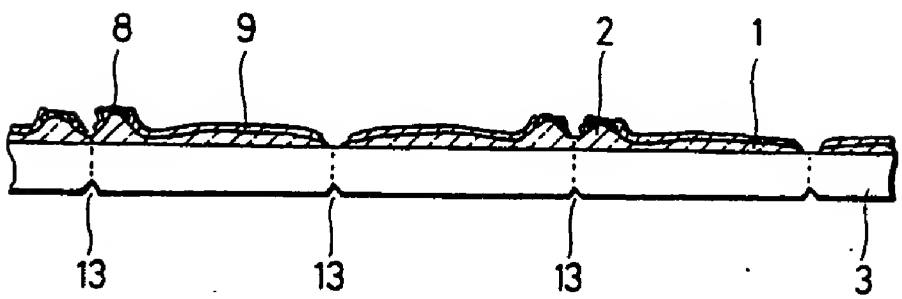

FIG. 8

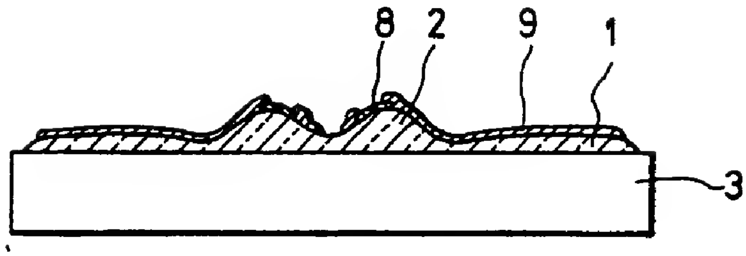

FIG. 9

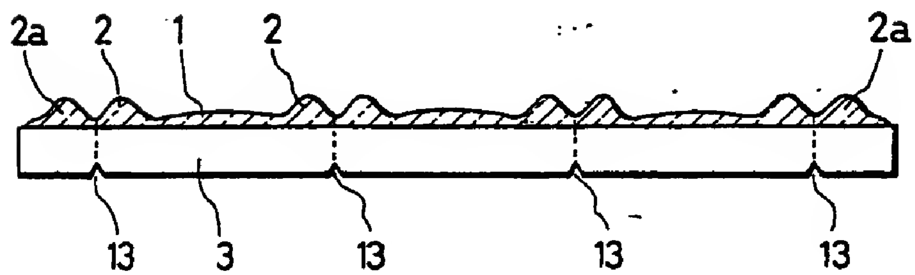

FIG. 10

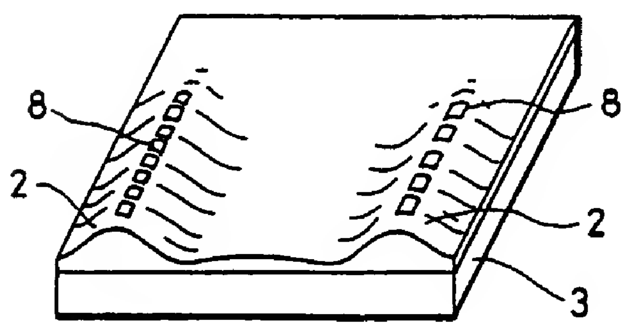

FIG. 11(A)

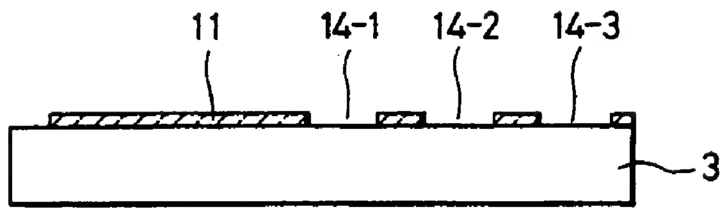

FIG. 11(B)

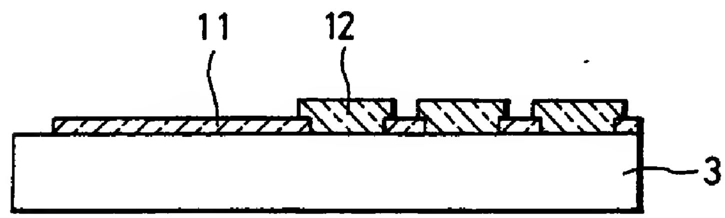

FIG. 11(C)

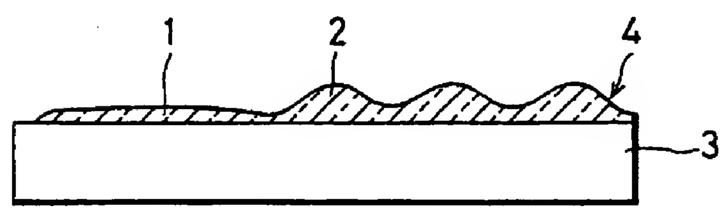

FIG. 11(D)

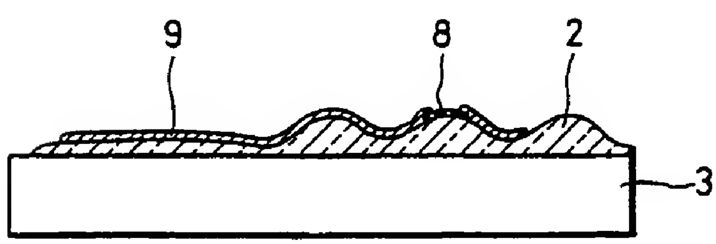

FIG. 12(A)

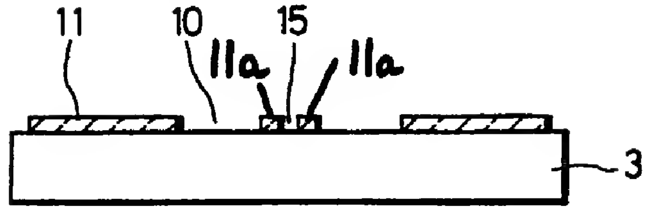

FIG. 12(B)

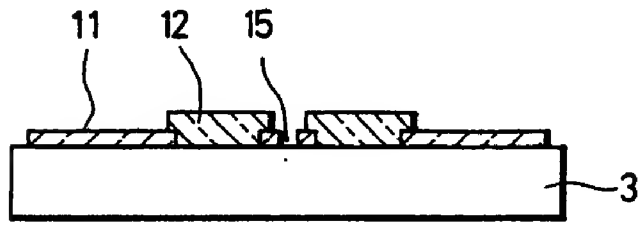

FIG. 12(C)

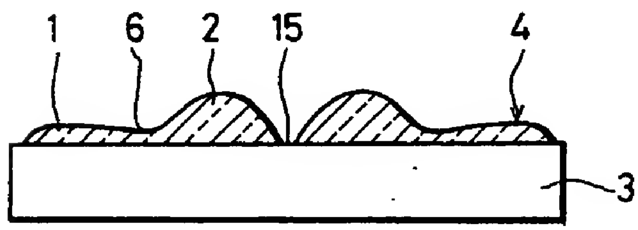

FIG. 12(D)